DOCUMENT RESUME

ED 298 551 CS 506 322

AUTHOR Dow, Caroline; Covert, Douglas C.
TITLE Monitor Tone Generates Stress in Computer and VDT Operators: A Preliminary Study.
PUB DATE Jul 88
NOTE 24p.; Paper presented at the Annual Meeting of the Association for Education in Journalism and Mass Communication (71st, Portland, OR, July 2-5, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Auditory Discrimination; Computer Peripherals; Computer Terminals; *Females; *Hearing (Physiology); Noise (Sound); *Occupational Diseases; Occupational Safety and Health; Psychological Studies; *Sex Differences; Stress Variables; *Video Display Terminals
IDENTIFIERS *Stress (Biological)

ABSTRACT

A near-ultrasonic pure tone of 15,570 Herz generated by flyback transformers in computer and video display terminal (VDT) monitors may cause severe non-specific irritation or stress disease in operators. Women hear higher frequency sounds than men and are twice as sensitive to "too loud" noise. Pure tones at high frequencies are more annoying than broadband noise at the same level. Because hormonal levels influence sensitivity to high frequency sound in both men and women, stress symptoms may be intermittent, but all who hear the pure tone are affected. Meaningless noise may induce physiological changes in stroke volume of the heart, pulse amplitude, dilatation of the pupil, the ability to quickly change focus of the eyes or move the eyes through certain angles. A survey of 38 students in two college classes using the same classroom equipped with 21 desktop computers revealed that 15 students (12 of them women) could hear the high-pitched sound. Nearly all 26 female students reported stress decreased noticeably shortly after computer monitors were turned off. Two sets of acoustical measurements were made in this classroom, one by an audiologist and one by an acoustical engineer. Both tests indicated a distinctive pure-tone sound at the 16 kHz frequency. Past studies of VDT health effects have not considered pure-tone sound or gender effects as possible causes of stress and stress disease symptoms in computerized workplaces or classrooms. (One table of data and 47 notes are included.) (SR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Caroline Dow
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED298551

MONITOR TONE GENERATES STRESS IN COMPUTER AND VDT OPERATORS: A Preliminary Study

by

Caroline Dow, Ph.D. and
Douglas C. Covert, Ph.D.

Copyright © Caroline Dow and Douglas C. Covert, 1988

Dept. of Communication
University of Evansville
1800 Lincoln Ave.
Evansville, IN 47722

CS506322

ABSTRACT

MONITOR TONE GENERATES STRESS
IN COMPUTER AND VDT OPERATORS:
A Preliminary Study
by
Caroline Dow, Ph.D. and
Douglas C. Covert, Ph.D.

A near-ultrasonic pure tone of 15,750 Herz generated by flyback transformers in computer and VDT monitors may cause severe non-specific irritation or stress symptoms in operators. Women hear higher frequency sounds than men and are twice as sensitive to "too loud" noise. Pure tones at high frequencies are more annoying than broadband noise at the same level. Because hormonal levels influence sensitivity to high frequency sound, in both men and women, stress symptoms may be intermittent, but all who hear the pure tone are affected. Meaningless noise may induce physiological changes in stroke volume of the heart, pulse amplitude, dilatation of the pupil, the ability to quickly change focus of the eyes or move the eyes through certain angles. Past studies of VDT health effects have not considered pure-tone sound or gender effects as possible causes of stress and stress disease symptoms in computerized workplaces or classrooms.

MONITOR TONE GENERATES STRESS IN COMPUTER AND VDT OPERATORS: A Preliminary Study

Copyright © Caroline Dow & Douglas C. Covert, 1988

Research into causes of physiological and psychological stress in computer and VDT operators has focused on both ionizing and nonionizing radiation. These investigations have found no apparently harmful ionizing radiation in current VDTs, but complaints and symptoms persist. Current research suggests previous studies may have been improperly focused and that women are far more seriously affected than men.

Commonly reported symptoms are eyestrain, double vision, headaches, fatigue, general irritability, back pain, shoulder cramps and wrist problems. Some of these complaints may be reduced or eliminated by changing physical configurations in the workplace. Headaches, unaccustomed fatigue, irritability and some of the vision problems have resisted alleviation, often resulting in lowered productivity, especially in the quality of output.[1] There is growing evidence that stress caused by near-ultrasonic sound emanating from the terminals is an important contributor.[2]

A flyback transformer in VDTs and computer monitors enables the electronic system to write an image on the viewing screens. This transformer also produces a pure-tone sound in the upper range of human hearing.

The flyback transformer generates nonionizing radiation at 15,750 Herz (Hz) in most current models of VDT and computer viewing monitors. Commonly called 16 kHz radiation, this frequency is in a range sometimes known as "very low frequency" (VLF). This VLF radiation can be biologically active as has been demonstrated in animal research,[3] but researchers have not been able to understand how this weak radiation can cause difficulty in humans with their increased body mass.[4]

VLF nonionizing radiation is usually perceived to be electrical, and suggestions have been made to use some sort of metallic shielding with grounding to "drain off" the electrical field.[5] Newer models of computers and VDTs generally have such shielding to meet FCC regulations for controlling electromagnetic radiation -- e.g., avoiding interference with radio and other electromagnetic systems.

However, terminology distinctions must be made between audio pressure waves and electromagnetic radio waves. The audio band representing the range of normal human hearing is generally considered to be between 20 Hz and 20 kHz. (Generally, any sound above the range of human hearing is called ultrasonic.) In the human-hearing range, a 16 kHz tone is quite high in frequency. Radio waves below 30 kHz are in the VLF band.[6]

It is easy for researchers to become confused in labelling and discussing the 16 kHz frequency. Audio or acoustic pure-tone frequencies near the high end of the range audible to

humans, just below frequencies commonly identified as ultrasonic, should not be treated as VLF radiation.

A preliminary investigation points to a 15,750 Hz acoustical radiation -- sound -- from the flyback transformer, rather than the customary perception of electromagnetic nonionizing radiation or pulsed magnetic fields, as significant in creating high levels of stress which then result in physiological discomfort and stress disease.

Ultrasound Effects on Animal Tissues

Several studies of the effects of ultrasound should be noted in order to offer some perspective on the potentials of higher frequencies at elevated acoustical pressures. These studies have used animal subjects and have been principally concerned with mechanical transmission into and through tissue. Most ultrasound research has concentrated on frequencies of 20 kHz and above. In fact, there has been a notable gap in studied frequencies. Published literature tends to report research on audible sound up to about 12.5 kHz, then ultrasound research commonly begins at 20 kHz.

An hour or more of exposure to ultrasound frequencies of 20 kHz at decibel levels from 95 to 130 has shown biological changes in animals such as rats and rabbits In humans, such exposures have resulted in heating of body surfaces and especially skin clefts.[7] Malformations in chick embryos exposed to weak pulsed-magnetic fields have also been demonstrated but not successfully replicated.[8] At high sound-pressure levels,

tissue destruction may occur in animals. Fortunately, human skin has a poor acoustical impedance match with air and does not respond as readily as the furred or feathered skin of animals. But, the human ear structure is a better impedance match than skin and can more effectively transmit ultrasound to the fluid medium of the inner ear.[9]

Human Response to Noise

"Noise" is difficult to define except in the most general terms, such as "any undesireable sound (or signal)."[10] Also, it becomes necessary to distinguish between meaningful noise, which individuals may associate with some recognizable phenomenon, and meaningless noise such as the white noise of hearing science, unrecognizable sounds not associated with any familiar phenomena or sounds which become meaningless over time such as those of air handling systems. To be objectionable, noise usually must reach a certain loudness level. Objectionable loudness levels vary, however, with frequency or complexity or both.[11]

Meaningful noise may cause stress reactions when first encountered, although humans soon accommodate when it is of short duration and repeated often enough. However, noise without meaning may induce significant physiological changes, even upon repetition. Tests using broad-band, meaningless (white) noise on humans at 90 decibels caused vasoconstriction in the skin, reduction of pulse amplitude, decrease in stroke volume of the heart, and dilatation of the pupil, even for

people accustomed to the noise.[12] The eyes may also lose the speed with which they adjust focus on near and far objects and move through certain angles.[13]

Either continuous or periodic noise may cause people to become tired or irritable, even if it is not extremely loud. And, human response to noise is difficult to predict. A continuous pure tone is not as well tolerated as the variable, wide ranging tones and fluctuating sound intensities of ordinary living and working quarters. "... pure tones, especially at high frequencies, are much more annoying than a broadband noise at the same level."[14] High-pitched pure tones are irritating in any environment.[15]

Studies of industrial ultrasound have ruled out hearing loss from airborne ultrasound at pressure levels below 110 dB. However, these studies found "subjective effects" among those entering an industrial ultrasound field, where frequencies are usually above 20 kHz. These are commonly described as "an unpleasant sensation of 'fullness' or pressure in the ears ... followed by a sort of tinnitus, nausea, headaches and possibly fatigue.... These appear to be threshold effects dependent on the sound level. Their onset is not closely related to duration of exposure or sound energy, although people's tolerance of these conditions naturally diminshes with increasing periods of exposure. These effects usually disappear upon or shortly after cessation of exposure."[16] These same studies found that "these subjective effects are often only reported by the young females

among a working population" and attributed this to more sensitive hearing of the higher frequencies in this group.[17]

The International Labor Office has adopted 16 kHz as the lower level for ultrasound protection standards.[18] Most ultrasound standards have been based on high sound pressure levels (SPL), above 60 decibels (dB), since those noise levels are encountered in industrial settings. If we could hear these ultrasound noises, we would consider 60 dB pressure levels on the A-weighted scale (representing normal human hearing) loud enough to be annoying or irritating.

One frequently noted study found women in an industrial setting experienced stress disease symptoms while exposed to a 16kHz sound output. The symptoms were relieved by enclosing the offending machines in sound-damping boxes.[19] The study was concerned especially with the possibility of hearing damage and found that recognizable physiological effects appeared between 76 and 78 dB. It found women more susceptible to distressing physiological symptoms of the 16 kHz sound than men, but then discounted this sex difference. The investigators were apparently unaware of the difference in high frequency auditory acuity between men and women. One of the investigators in this study (Acton) often has been credited with establishing the international standard of 75 dB maximum for the 16 kHz sound.

Loudness, Frequency and Sex Differences

The ordinary living room, when unoccupied, has an average decibel level of about 25 dB, rising to about 45 dB when there

is common activity including ordinary conversation. An office typing room (or typewriter-equipped newsroom) averages about 65 dB, industrial noises of riveting machines and jack-hammers at 30 feet near 100 dB and humans begin to feel sound waves at about 120 dB, a pressure level which may cause pain in the ears. A sound level "of 60 dB would pose some difficulty in telephone use and would require raising the voice in order to have intelligible conversation for talker-listener distances of 3 ft, and a loud voice for talker-listener distances of 7 ft."[20] Conversation at 60 dB is comfortable for most people, but noise or competitive sound at the same SPL is not.

Age and sex factors should enter into studies of acoustic radiation effects, but commonly have been ignored. Loud or too-loud noises are generally subjective descriptions and we can become accustomed to some meaningful loud noises, but physiological differences between men and women produce notable differences in their criteria for "too loud." In the normal range of ambient sound frequencies, women identify broad-band noise as too loud at levels 8 to 10 decibels below that of men.[21] The logarithmic decibel scale makes comparisons of measurements difficult, but this difference in subjective perceptions of auditory excess means that men do not identify sounds as "too loud" until they are two or more times as loud as the limit for women.[22] There is no reason to believe that a similar difference does not occur at higher frequencies.

Normal human hearing lies within the 20 to 20,000 Hz range. Men in their 20s and 30s ordinarily do not hear

frequencies much above about 15 kHz. Women in the same age range hear frequencies 1 to 3 kHz above men. Therefore, the sound emanating from monitors is more likely to affect women than men due to differences in their hearing range. There is an age-related decrease in pure-tone sensitivity, but, at any age, the sensitivity to high frequency sounds is higher in women than in men.[23] Thus, young women are more likely to experience consequences than older women or young men.[24]

Furthermore, limited tests also indicate a variation in sensitivity to high-frequency sound with changes in sex hormone levels, in both men and women but particularly in women.[25] Young women at peaks of their menstrual cycle, pregnant or taking many forms of birth control pills will be most sensitive and susceptible to the effects of pure-tone sound at the higher frequencies.[26]

For several years, efforts have been made by working groups especially involved in VDT use such as the Newspaper Guild and "9 to 5," the National Association of Working Women, to promote studies of VDT radiation problems and establish federal standards. Statistical clusters of birth defects and miscarriages found in some of the earlier studies have caused considerable alarm and many of those who work with VDTs, and their colleagues, have not put much stock in the claim that the clusters are an expected consequence simply because so many women work on VDTs.[27]

It has been common in the literature to refer to "subjective effects" of headache, fatigue, etc. These effects

are usually described as occurring at sound pressure levels above 76 dB. However, the subjective-effects complaints have been discussed as physical or recognizably physiological. Nothing in the available literature mentions the possibility of sound pressure levels being stressful below that at which the physical symptoms appear. The assumption, apparently, is that the onset is sudden, with no prelude. The irritation and fatigue reported by VDT operators could be precursive symptoms of the physical subjective effects reported at higher sound pressure levels, especially with the increased auditory acuity of women.

Measurements and Responses in One Classroom

In a survey of 38 students in two college classes (one male and one female instructor) using the same classroom equipped with 21 desktop computers, 13 could hear the high-pitched sound easily and two more when attempting to concentrate their attention on demanding work, trying to block out other sounds. Of these 15, 12 were women with ages ranging from 20 to 40+. In anecdotal tests in the two classes, nearly all of the 26 female students reported stress decreased noticeably shortly after the computer monitors were turned off. In several classes using the same computer equipment in two different rooms, women students complained of headaches at the conclusion of class; some volunteered without prompting that it was the sound of the machines that bothered them.[28]

Class one	Sound	No sound	Total
male	2*	4	6
female	8	7	15
total	10	11	21

*Ages 20 and 22.

Class two	Sound	No sound	Total
male	1*	5	6
female	4	7	11
total	5	12	17

*Age 17.

Two sets of acoustical measurements were made in this classroom, one by an audiologist and the other by an acoustical engineer. Both tests indicated a distinctive pure-tone sound at the 16 kHz frequency.

The sound level meters typically used by audiologists are reliable instruments at frequencies through 8 kHz. Although they provide valid and repeatable measurements through 16 kHz, they commonly require a calibration factor for frequencies above 10-12 kHz.[29] An audiologist's meter, adjusted for the 16 kHz frequency, recorded an average 47 dB SPL peak reading in an operator's position in front of several monitors in the tested classroom, 16.5 dB more than the 8 kHz reading.[30]

Tests by an acoustical engineer, using a sound level meter accurate through 20 kHz and a 1/3 octave filter set,[31] found a pure tone and sound pressure peak at the 16 kHz frequency,

unaccompanied by other sound level increases. The average decibel level of this tone at all four sides of the computer monitors[32] was between 36 and 43 dB with a high of 48 dB, reaching an occasional high level of 53 dB. Some monitors were louder than others so that each monitor had its own dB level, varying up to 5 dB in moving from one side to another or front to back, whether the computer itself was on or off. In several cases, the SPL at operator position was as high or higher than any of the other three sides. Furthermore, the pressure level (intensity) of the tone was persistent throughout the room, falling only to 35 dB at a point farthest from the monitors -- about five meters (16 feet) -- and partially baffled from sound reflections.[33]

With all computers and monitors turned off to measure the ordinary sound levels with normal student activity including conversation, pressure levels of 41 dB to 70 dB were measured, with the most common levels between 55 and 65 dB. With all computer work stations turned on, sound levels ranged from 59 to 98 dB, the highest readings while some printers[34] were operating. The audiologist measured the printer alone, without other ambient sound and from the adjacent operator position, as 87 dB. These levels are considered typical of such a working environment.[35]

Analysis

The Council on Scientific Affairs of the American Medical Association has summarized the literature on health effects and

VDTs,[36] although the report tended to confuse VLF and audio discussions. The report referred to sound levels, then discounted sound as a factor: "High levels of VLF ultrasound (79 to 150 dB) in industry have been reported to cause symptoms that include temporary hearing loss, nausea, fatigue, headache, and tinnitus. However, the highest reported VLF sound level from VDTs is only 68 dB."[37] The bandwidth at 68 dB was not identified in the report.

The Council's "highest reported" sound level came from the Bureau of Radiological Health report which gave a peak of 68 dB at 40 kHz, and 61 dB at 16 kHz,[38] 14 dB below the limit recommended by the International Labor Office and adopted by the World Health Organization (WHO) in 1977 for 16 kHz and higher frequencies. The BRH reported on 14 different monitor brands, with 16 kHz sound levels ranging from 41-61 dB at the operator's position.

All of the studies surveyed were concerned with hearing damage, not stress disease. None of the studies supporting these standards considered sex-differences or hormonal changes in hearing range or loudness perception; the standards were intended to apply to men and women alike.

The Council report dismissed noise as a factor. "Depending on the internal location of the transformer, very little exposure could be expected for an operator seated at the front. The amount of noise, even at the source, could be reduced to near zero with component shielding."[39] However, measurements in the classroom indicated the sound was almost equal on all sides

of the monitor and in some cases was greater at the operator position. Furthermore, retrofitting existing machines to alleviate the 16 kHz noise would be difficult.[40] Again it appears the Council report confused VLF and audio.

Many past studies have been faulty for one reason or another, but sound effects "have not been studied extensively."[41] In fact, studies now underway or proposed will be confounded and faulty unless the pure-tone 16 kHz output, the gender and hormonal differences, and the variations among monitor brands and individual unit outputs are included. The Office of Management and Budget demanded that a VDT study scheduled to begin in 1985 remove any questions relating to stress or fertility in VDT operators, although Rep. Ted Weiss (NY) of the Committee on Government Operations opposed the OMB changes and urged the Secretary of Health and Human Services (Dr. Otis Bowen) to override the OMB deletions. Weiss said, "Since stress could cause infertility or miscarriages, removing these questions could make any results impossible to interpret."[42]

Further anecdotal support of the stress effects of VDT use was provided by two female copy editors at a local daily newspaper. Both were considering leaving their positions because of their perception of unspecified job stress.

One complained in a personal conversation that she could not understand why she seemed to experience the most distress at work when at the top of her cycle (the time of greatest fertility) when these were usually her most productive days.

When asked, she reported that she sometimes heard an annoying, high-pitched sound from her VDT monitor. She then was asked to use a pair of foam earplugs when she could hear the sound. She subsequently reported significant stress reduction while wearing the earplugs, a gain in productivity and overall higher job satisfaction -- and is still a copy editor.

A co-worker heard the high-pitched sound almost continuously. She, too, adopted the earplugs and reported similar stress reduction accompanied by improved job satisfaction.[43]

Conclusions

Research has shown that low sound intensities at ultrasonic frequencies can have physiological effects, annoyance from sound becomes greater as the pitch approaches the top of the hearing range, sounds slightly above hearing range still have an effect in spite of their inaudibility, women are more sensitive to pitch and loudness than men, age reduces sensitivity to high-pitched sound, and hormone levels affect sensitivity to pitch and loudness. It is highly likely, because of established hearing differences between men and women, that the 16 kHz pure-tone will create a significant stress response in some women while most men find the tone either inaudible or not loud enough to be objectionable. This does not exclude similar stress responses in men with extraordinary hearing, and some women will not hear the tone.

Assumptions have been made that task performance expectations with computerized technology are inherently more stressful, and such explanations of reported problems may be true. It is also possible that stress may be a result of non-machine related working conditions, or personal problems not job related. Fear of change is real enough in some people to generate stress disease symptoms, especially when it appears that the worker may be displaced because of the change, although technological displacement fears seem unlikely among most newsroom workers or students. But, the conclusion of the AMA's Council on Scientific Affairs that "the levels have been well below presently accepted standards of exposure"[44] may be based on the faulty premise of presently accepted standards (and possible confusion between electromagnetic VLF and audio pressure levels). The Council's extensive literature search either failed to find or discounted studies pertinent to the 16 kHz pure-tone or to note sex-related differences, the latter a major oversight.

Men commonly make computer hardware adoption and evaluation decisions but women are more seriously affected by the choices. When men cannot hear monitor-generated sounds or are not apparently affected by them, they discount complaints by women as "computerphobia" (or "cyberphobia") or lack of willing productivity, in quantity or quality. Women may experience, and have recited, unidentifiable irritation in the workplace, which may approach antagonism, and not understand

that there may be a real physiological and psychological cause agent at work.

The potentials in these sound effects have important implications for women in the workplace and the classroom. Efforts should be made immediately to determine any relationship between this 16 kHz sound and the distress experienced by computer and VDT operators.

Extensive testing of human subjects may be necessary to accurately determine sensitivity variation and the effects which may result from this sound output. Possible effects on the computer industry are far-reaching; it is difficult to retrofit existing monitors to reduce the 16 kHz sound intensity significantly.[45] And, of course, some monitors do not emit the tone at sufficient loudness to have any effect, while others are commonly referred to, even by men, as "squealers."

Bulky hearing protectors are probably unnecessary to reduce this pure tone and would be unacceptable in most office workplaces. At present, foam earplugs designed to attenuate all audible noise, without impeding conversation or telephone use, and which significantly absorb high frequency sounds appear to be one of the most satisfactory and acceptable temporary solutions.[46]

Noise-cancellation systems may be appropriate in some workplaces. These systems fill the work space with the same sound or sounds 180° out of phase with the offending sounds. Indeed, some high-priced automobiles are scheduled for manufacture with such noise-cancellation, costing about $300

and built into their stereo systems, to nearly eliminate road noises.[47] If such systems can be justified in our cars, surely something similar can be done for the workplace.

NOTES

[1]"Rhode Island Gets Bill on VDT Safety," The Guild Reporter, June 10, 1984; "VDT Operator Wins Worker's Comp," Ms, March 1984, p. 21; "State Sets Session on VDT-use Rules," The Guild Reporter, March 9, 1984; "Debate Continues on VDT Hazard Issue," Presstime, April 1984, p. 40; "ANPA Calls VDT Legislation Impediment," The Guild Reporter, June 15, 1984; "Multi-Union Conference Backs Gov't VDT Standards," The Guild Reporter, Dec. 14, 1984; "ANPA Lists Steps for VDT 'Comfort'," The Newspaper Guild, Feb. 22, 1985; "VDT Bills Sprouting in Record Numbers in '85 Legislatures," The Guild Reporter, March 22, 1985; "Eisen, VDT Makers' Rep Air Differences on Solutions," The Guild Reporter, March 22, 1985; "Consumers Union Tests VDT Operators' Eyes," The Guild Reporter, May 24, 1985; "VDT-Regulation Foes Open Central Office," The Guild Reporter, May 24, 1985; "First VDT Eye Clinic Opens," Associated Press, Sept. 25, 1985.

[2]D.S. Chatterjee and A.J. Crookes, "VDUs and Relative Annoyance from High Frequency Noise," Journal of Occupational Medicine, 26:552-53 (No. 8, August 1984).

[3]Louis Slesin, "VDT Emissions: What Is, Isn't Known," The Guild Reporter, March 8, 1985.

[4]Ibid.

[5]"Report Said to Back VDT Shielding," The Guild Reporter, April 26, 1985; "Advisory to Locals Addresses VDT Emissions Tests, Shields," The Guild Reporter, Oct. 11, 1985; "New Shield Blocks VLF Emissions," The Guild Reporter, Jan. 13, 1984; "IEB Urges New Shield Push, Tests on VDTs," The Guild Reporter, May 10, 1985.

[6]One wavelength of a 16 kHz acoustic wave is about 1/16 inch or 2 mm. One wavelength of a 16 kHz radio wave is about 5,000 meters.

[7]W.I. Acton, "Exposure to Industrial Ultrasound: Hazards, Appraisal and Control," J. Soc. Occupational Medicine, 33:107-113 (1983), p. 108.

[8]Slesin, op. cit.; "IEB Urges New Shield Push, Tests on VDTs," The Guild Reporter, May 10, 1985, (study conducted by Dr. José Delgado, Centro y Cajal Hospital, Madrid, Spain).

[9]Acton, p. 108.

[10]John D. Durrant and Jean H. Lovrinic, Bases of Hearing Science, 2nd Ed., Baltimore: Williams and Wilkins, 1984, p. 66.

[11]Durrant and Lovrinic, Ch. 7.

[12]Gerd Jansen, "Effects of Noise on Physiological State," Proceedings of the Conference "Noise as a Public Health Hazard", Washington, D.C.: The American Speech and Hearing Association, Feb. 1969, pp. 90-1.

[13]Alexander Cohen, "Effects of Noise on Psychological State," Proceedings of the Conference "Noise as a Public Health Hazard", Washington, D.C.: The American Speech and Hearing Association, Feb. 1969, p. 76.

[14]Environmental Noise Measurement, Denmark: Bruel & Kjaer, 1986, p. 12.

[15]Cohen, p. 80.

[16]Acton, p. 109

[17]Acton, pp. 109-10.

[18]Acton, p. 110.

[19]W.I. Acton and M.B. Carson, "Auditory and Subjective Effects of Airborne Noise from Industrial Ultrasonic Sources," Brit. J. Industr. Med., 24:297-304 (1967), p. 298.

[20]Cohen, p. 75.

[21]Diane McGuinness, "Hearing: Individual Differences in Perceiving," Perception, 1:468 (1972).

[22]Paul B. Christensen, "Psychoacoustics: The Science of Sound Perception," Broadcast Management and Engineering, April 1987, p. 52.

[23]Ronald Gandelman, "Gonadal Hormones and Sensory Function," Neuroscience & Biobehavioral Review, 7:1-17 (1983).

[24]James Jerger and James Hall, "Effects of Age and Sex on Auditory Brainstem Response," Arch. Otolaryngol. 106:387-391 (July 1980); McGuinness, 1:465-473 (1972).

[25]V.T. Wynn, "Measurements of Small Variations in 'Absolute' Pitch," Journal of Physiology, 220:627-637 (1972); K. Paul Satinder and Laura M. Mastronardi, "Sex Differences in Figural After-Effects as a Function of the Phase of the Menstrual Cycle," Psychologia, 17:1-5 (1974); Gandelman, op. cit.

[26]Diagnostic ultrasound during pregnancy is an approved medical practice; such exposure is irrelevant to ultrasound's potential auditory effect.

[27]"VDTs and Babies--Apprehensions Persist," The Guild Reporter, Jan. 13, 1984; "NIOSH Urged to Investigate Birth Abnormalities' Cluster," The Guild Reporter, Feb. 24, 1984; "Report Said to Back VDT Shielding," The Guild Reporter, April 26, 1985; Henry Weinstein, "Unions, Women's Groups Push for Regulation of VDT Use," Los Angeles Times, Aug. 11, 1985; "OMB Nixes Study of VDTs and Pregnancy," The Guild Reporter, Jan. 10, 1986; "Researchers at Michigan Study Data on VDTs and Pregnancies," The Guild Reporter, March 14, 1986; "OMB Imperils VDT Health Risk Study," Sexuality Today Newsletter 10(25):2, April 6, 1987.

[28]Both instructors had taught the same demographic mix of students in the same or similar courses for several years in typewriter-equipped labs with no reports of unusual stress problems. The sudden rash of apparently stress-related complaints, which seemed to be gender-specific, appeared when the typewriters were replaced by computers. The phenomenon sparked this search for possible causative factors.

[29]Jerry L. Punch, Ph.D., Audiologist, Riley Memorial Hospital for Children, Indianapolis, Indiana, interview, Feb. 3, 1987.

[30]-----, "Report of sound levels measurements in computer classroom," Feb. 4, 1987.

[31]Bruel & Kjaer type 2230 integrating sound level meter, Bruel & Kjaer type 1625 1/3 octave filter set.

[32]Amdek 12" Data Display monitors, model Video 300, manufacture date 1984.

[33]David A. Larson, Field Applications Engineer, Bruel & Kjaer Instruments Inc., Indianapolis, Indiana, "Summary report of measurements made in journalism classroom," March 3, 1987.

[34]Epson Spectrum LX-80 printers, model P87RA.

[35]David A. Larson, "Summary"; Jerry L. Punch, "Report."

[36]Council on Scientific Affairs, American Medical Association, "Health Effects of Video Display Terminals," JAMA, 257:11, 1508-12 (March 20, 1987).

[37]Ibid., p. 1509.

[38]U.S. Department of Health and Human Services, An Evaluation of Radiation Emission from Video Display Terminals, Bureau of Radiological Health, FDA 81-8153 (Rockville, Md.:

Bureau of Radiological Health, February 1981), pp. 18-19, 34-35.

[39]Council on Scientific Affairs, p. 1509.

[40]Elliott H. Berger, Manager, Acoustical Engineering, E-A-R Division, Cabot Corporation, personal communication, Feb. 23, 1987.

[41]Council on Scientific Affairs, p. 1509.

[42]Council on Scientific Affairs, p. 1511; Ted Weiss, "House Report Blasts Federal Response to Health Hazards in Workplace," press release, October 16, 1986; "OMB Imperils VDT Health Risk Study," Sexuality Today Newsletter, 10(25):2 (April 6, 1987).

[43]This co-worker was in early pregnancy. Her gynecologist attributed two preceding miscarried pregnancies to stress. She completed this pregnancy successfully.

[44]Council on Scientific Affairs, p. 1511.

[45]Berger, op. cit.

[46]Acton, p. 111-2; Berger, op. cit.

[47]James Arnold, Field Applications Engineer, Bruel & Kjaer Instruments Inc., Indianapolis, Indiana, personal communication, 13 May 1988.